

## Body part study from real life accidents for a new SID (Side Impact Dummy)

**Tjark Kreuzinger, Stephan Knack**

Federal Highway Research Institute (BASt)  
Germany

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### SUMMARY

The purpose of this paper is to review injuries found in real world lateral collisions and determine the mechanisms responsible for certain kinds of biomechanical failure.

During the last years the distribution of deaths among the different types of accidents has changed. Lateral collisions now are the most frequent cause of fatal and other serious injuries [1], [2]. Every third accident is an impact from the side, while every second fatality is the result of a lateral accident. Just a few years ago this value was no higher than 30% .

This is probably the result of increasing safety standards for frontal collisions (airbags, seatbelt usage, structural improvements of cars, etc.). Although the number of registered vehicles increased, the total amount of fatalities decreased during the same period. Thus it is now necessary to pay greater attention to the lateral accident situation in order to improve road safety and decrease the number of traffic injuries.

Several European organisations had decided to launch the project SID2000, which was funded by the European Commission, with the intention of gathering more knowledge on injuries occurring in lateral accidents and the mechanisms that lead to such injuries. This should enable the group to define the requirements for a new side impact dummy (SID) to be designed. Within the same project the existing TNO-EUROSID1 was enhanced by another group and the experience gained has now enabled allowed to design a better measuring device for side impacts. The data used for this contribution came from sources from all over Europe and had to be gathered in such a manner that as many accident parameters as possible were taken into account.

### INTRODUCTION

One fundamental requirement for a valid dummy is well-founded knowledge regarding the injuries

occurring in real life accidents. This paper describes how this task was carried out.

The data sources for accident analysis were *LAB - Laboratory of Accidentology and Biomechanics* [3] made available by *INRETS - Institut National de Recherche sur les Transports et leur Sécurité*, both French institutes, *CCIS-Co-operation Crash Injury Study* [4] made available by *TRL - Transport Research Laboratory*, both United Kingdom, *VOLVO* [5], Sweden and *BMW - Bayerische Motorenwerke* [6] and *MUH-Medical University of Hanover* [7] made available by *BASt - Bundesanstalt fuer Strassenwesen*, all Germany. During analysis the body parts injured most frequently were determined and the severity of the injuries was taken into account. The sensoric equipment for the planned dummy was established to match real life requirements. It was necessary for this to be carried out in accordance with the main objective of the project: obtaining the best possible validated instrumentation for a new dummy. After analysis, it is possible to fabricate and test prototypes of dummy parts. In some cases redesigned parts can be implemented in the existing TNO-EUROSID1. A comparison to the prior performance specifications is necessary for final revision of the body part requirements.

This work resulted in a number of new demands that were taken into consideration in the subsequent design process for a new SID.

### DATA SOURCES

It was always necessary to take into account that the data sources came from different organisations and thus could not be compared directly. The original intentions of the various organisations did not necessarily coincide. For instance a car manufacturer will only be interested in accidents where his own cars were involved. A public institute will provide information on all existing cars but is often limited to a certain region. Therefore the first task is to collect all data and list the various findings resulting from the organisation's aims and acquisition techniques.

All data was analysed separately in order to determine any inhomogeneous premises of the data. The data was divided up into two parts: Sample one = car-to-car accidents and sample two = car-to-fixed-obstacle accidents such as trees, crash barriers, buildings, walls, poles, posts and road signs. In the beginning the human body was divided up into body regions., namely head, neck, spine, thorax, abdomen, pelvis and limbs. For being considered all data had to fulfil certain requirements. All vehicles had to have a self-supporting body. The considered injured passengers were sitting on the struck side and have not been totally ejected. The injured occupants were 10 years of age or older and 1.40 m or more tall. The direction of impact was between 2 and 4 or 8 and 10 o'clock. There was always direct intrusion on the occupant. In order to eliminate the possibility of considering accidents which were too insignificant, the minimum speed had to be 10 km/h (car-to-car accidents) or 15 km/h (car-to-fixed-obstacle). The speed should be given in EES (Energy Equivalent Speed) however, if not available, ETS (Equivalent Test Speed),  $\Delta v$  (change of speed) or closing speed were also sufficient to fulfil the requirement. None of the accidents should have occurred more than 14 years previously. Only primary impacts and no roll-overs were taken into account.

Two of the most important requirements were the availability of profound medical information of the injuries sustained in the accident and the deformation to the cars involved. In order to make the data sources more comparable only cases with AIS (AIS = Abbreviated Injury Scale, [8]) values of 2 and higher were taken into account. Otherwise data sources such as VOLVO with a large number of uninjured or slightly injured occupants in their database would distort the findings. Only the highest AIS value for each body region was considered. This means if several injuries with AIS values of 2 and 3 are present only one AIS3 injury was taken into account.

## **France**

The data from LAB consists of 115 accidents from which 82 impacts were in the car-to-car sample and 33 accidents in a car-to-fixed-obstacle situation. In car-to-car accidents 85 occupants were implicated, in car-to-fixed-obstacle accidents the figure was 36. 117 body regions in car-to-car accidents were found with an AIS value of 2 or higher (AIS2+) while this number was 41 for car-to-fixed-obstacle collisions. This leads to a rate of 1.4 body regions with at least one AIS2+ injury per occupant for car-to-car and 1.1

for car-to-fixed-obstacle accidents. All accidents occurred after 1986.

## **United Kingdom**

301 accidents were found in the CCIS Data, 245 car-to-car and 56 car-to-fixed-obstacle collisions. In these accidents 335 implicated occupants were involved. 268 in car-to-car and 67 in car-to-fixed-obstacle accidents. 434 AIS2+ injuries to different body regions were found for car-to-car, 259 for car-to-fixed-obstacle. Thus the rate for AIS2+ injuries per occupant is 1.6 in car-to-car and 3.9 in car-to-fixed-obstacle situations. All accidents occurred after 1984.

## **Sweden**

The Swedish data from VOLVO consists only of accidents in which VOLVO's were involved. The number of accidents was not documented. 928 people were implicated in car-to-car and 110 in car-to-fixed-obstacle accidents. 186 body regions of the involved people in car-to-car accidents suffered AIS2+ injuries and 74 for car-to-fixed-obstacle accidents. This leads to 0.4 AIS2+ injuries per implicated occupant in sample one and 0.7 in sample two. All cars involved were built after 1985.

## **Germany**

The two sources from Germany are BMW (called Germany 1) and MUH (called Germany 2).

### **Germany 1**

The data from BMW consists only of accidents in which BMW's are involved. BMW reported 12 car-to-car side impacts. In these 20 people were implicated and 13 body regions suffered AIS2 injuries or higher. The injury rate per occupant was 0.7. For car-to-fixed-obstacle BMW reported 19 accidents with 34 implicated people. They suffered 29 AIS2+ injuries to body regions coinciding to a rate of 0.9 injuries per implicated occupant. All accidents occurred during or after 1987.

### **Germany 2**

The Medical University of Hanover only investigates traffic accidents in the region of Hanover. On the basis of a special weighting procedure the accident data from MUH is statistically representative for all of Germany. The data consists of 206 side impact accidents (142 car-to-car and 64 car-to-fixed-obstacle) in which 341 persons were involved (249 in

sample one and 92 in sample two). 141 body regions of the involved people in car-to-car accidents suffered AIS2+ injuries and 166 for car-to-fixed-obstacle accidents. The rate of AIS2+ injuries per implicated occupant is 0.6 for sample one and 1.8 for sample 2. The accidents investigated occurred in 1995 or later.

The tables below (Table 1 and Table 2) show a comparison of all side impact accident data from all countries. The number of accidents and occupants involved are indicated for each type of accident (car-to-car and car-to-fixed-obstacle). Also the number of injuries which the occupants suffered in the accidents and injuries per occupant are shown.

**Table 1: Comparison of data from car-to-car accidents**

	F	GB	S	D (1)	D (2)
No. of accidents	82	245	N/A	12	142
No. of implicated people	85	268	928	20	249
No. of body regions with AIS2+ injuries	117	434	184	13	141
No. of injuries per person	1.4	1.6	0.4	0.7	0.6
Accidents since	1987	1985	1985 (cars)	1987	1985

## ANALYSIS

As mentioned earlier the various data was analysed separately and the results were compared afterwards. This was necessary to eliminate findings resulting from inhomogeneous data from all over Europe.

**Table 2: Comparison of data from car-to-fixed-obstacle accidents**

	F	GB	S	D (1)	D (2)
No. of accidents	33	56	N/A	19	64
No. of implicated people	36	67	110	34	92
No. of body regions with AIS2+ injuries	41	259	74	29	165
No. of injuries per person	1.1	3.9	0.7	0.9	1.8
Accidents since	1987	1985	1985 (cars)	1987	1985

The AIS0 and AIS1 injuries are not included in the diagrams. All values were related to the absolute number of AIS2+ injuries per sample and source. This was accomplished to make the different sources more comparable and more assessable.

## France

Only AIS values higher than one were considered. All totalled 117 body regions were analysed that had at least one injury of a severity of AIS2+. In contrast to frontal accidents hardly any neck injuries were found, nor was the spine injured frequently. The pelvis and the limb injuries were slightly more significant. These body regions suffered 11 and 14 % of the injuries with an AIS value of 2 or higher. The most important body regions were the head, thorax and abdomen. Even a considerable number of AIS5+ injuries occurred in these three groups.

Even though sample two includes only a low number of injuries (n = 41 AIS2+ injured body regions) the tendencies are similar to sample one. In addition there was one injury to the spine with an AIS value of 5+, whereby the spine was not significant in sample one.

## United Kingdom

Only a few neck injuries are present in all AIS2+ classes for sample one. The same applies for the spine. Injuries to the abdomen, pelvis and limbs were considerably more frequent, however, these did not include any in the AIS 5-6 category (nor any AIS4 injuries to the limbs). The most important AIS2+ injuries were those to the head and thorax, in terms of number as well as severity.

The injury distribution for sample two in principle is the same as in sample one. The major difference is that AIS2+ injuries to the limbs seem to occur with a significantly higher frequency in car-to-fixed-obstacles accidents than in car-to-car collisions.

## Sweden

In sample one the neck and spine are represented nearly equally with a low severity in some cases (2 and 3 % of all injuries). The abdomen, thorax and head tend to be more significant because they appear more often and also have the highest degree of severity (from 13 up to 26 % including some in the category AIS5+). The number of injuries to the pelvis and limbs is not low (10 and 18 %) however only 3 injuries were observed with an AIS value greater than 3. Nearly the same is true for sample

two. However, the limbs are affected more frequently (23 %) and the abdomen is slightly less significant (7 %).

## Germany

Two sources were available from Germany. BMW is designated Germany 1 and MUH is named Germany 2.

### Germany 1

Only a few accidents in sample one were severe enough to produce serious injuries. The body regions that were injured seriously were the head, thorax and abdomen. Only AIS2 injuries were present for the spine and limbs. Neither the pelvis nor limbs were severely injured in sample two. Neck spine and abdomen injuries seem to be more significant with a maximum severity of AIS4. The severest injuries were found for the head and thorax.

### Germany 2

This source also shows no cases of neck injury in sample one. Pelvis and limb injuries amount to approx. 13 and 14 % in categories AIS2 and AIS3. One AIS4 category injury was present for the pelvis (= 0.7 % of all AIS2+ injuries). Injury severities of AIS2, AIS3 and AIS5+ are present for the spine. The thorax and abdomen were injured quite frequently and severely (25 to 8 %; including category AIS5+).

The largest number of AIS2+ injuries suffered in this sample occurred to the head.

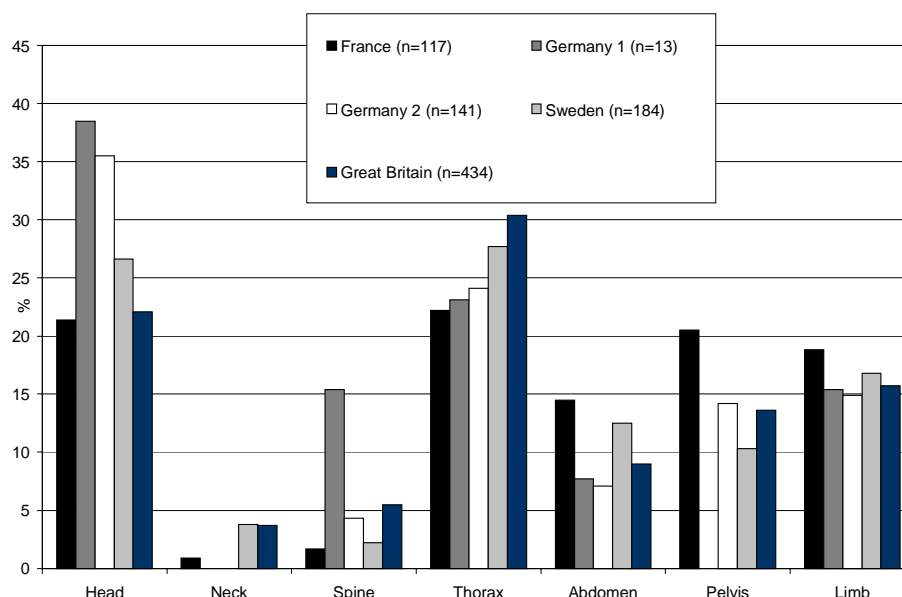
With the exception of the greater significance of the spine and pelvis the situation for the sample 2 is the same. Moreover one AIS5+ injury to the neck was noted, while the neck was not affected in sample one.

## COMPARISON / RESULTS

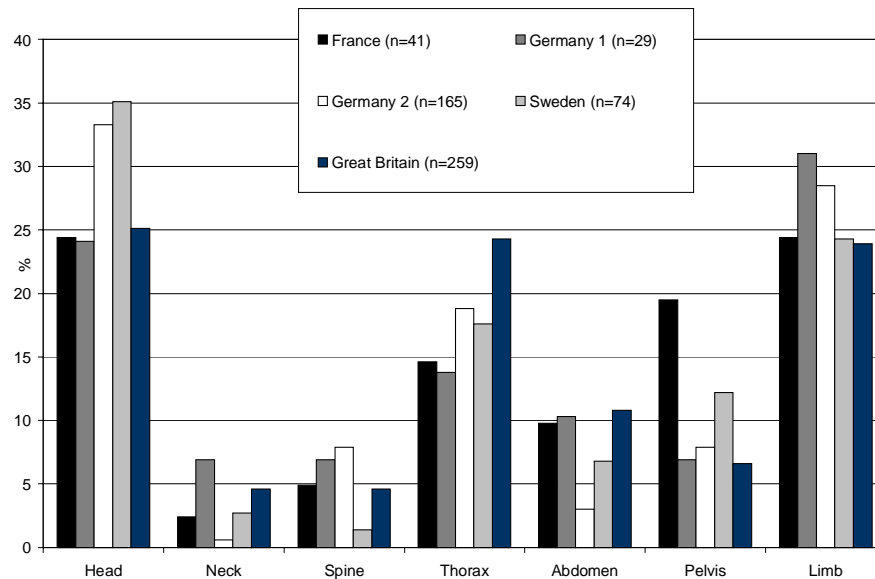
All data analysis was based on the absolute number of AIS2+ injuries per sample and source. This was accomplished to make the various sources more comparable and more assessable.

Figure 1 shows a comparison of the injuries with a severity of AIS2+ for all body regions for all occupants in sample one from all sources. The most important body region is the head followed by the thorax. An average of 29 % of all AIS2+ injuries occurred to the head whereby this value is 26 % for the thorax. This order is the same for nearly all data sources. The limbs are also of high significance (16 %, while keeping in mind the lower severity of the injuries). With 12 % the pelvis follows closely (less severe). Next is the abdomen with 10 %. Of considerably less significance are the spine and neck in this sample.

Figure 2 shows the same diagram for sample two. Again head injuries are dominant with an appearance of 28 %. In this sample the limbs are injured more frequently than the thorax (26 % and 18 %). The pelvis (11 %) is followed by the abdomen (8 %). The spine and neck are again of less significance.



**Figure 1: Comparison of AIS2+ injuries in car-to-car accidents in Europe: Injured body region in % per nation (all injuries per nation = 100%)**



**Figure 2: Comparison of AIS2+ injuries in car-to-fixed-obstacle accidents in Europe: Injured body region in % per nation (all injuries per nation = 100%)**

### DETAILED STUDY OF INJURIES

A more detailed study of the thorax and pelvis injuries was performed to specify where sensors should be placed in a new SID. Currently there are no sensors suitable for indicating injuries to the abdominal area. The data will be analysed in terms of the type of injuries and the injury mechanisms to provide information on how sensors for abdominal purposes should be designed. Again only injuries with an AIS2+ were mentioned.

First, when a detailed analysis is performed for a body part, the number of instances per body region and data source, which, in itself is not high, is divided up by a number of organs or bones/joints. This means that an absolute number of one case may already be mentioned as a significant percentage. To avoid misleading results, that can result from this fact, groups combining several anatomic units were defined for each body part. This procedure is only valid for organs located near one another and subject to the same injury mechanisms. For example the ribcage and clavicle are very close to each other, however certainly are not subject to the same injury mechanisms. Thus they can not form one group.

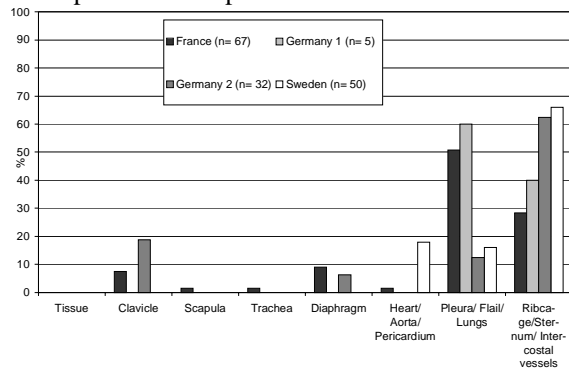
### Distribution of injuries among body regions

The data available for the thorax consisted of injuries to the tissue, clavicle, heart, aorta, scapula, ribcage, sternum, intercostal vessels, pericardium, flail (chest), pleura, lungs, trachea and diaphragm. The groups formed consist of: flail/pleura/lungs,

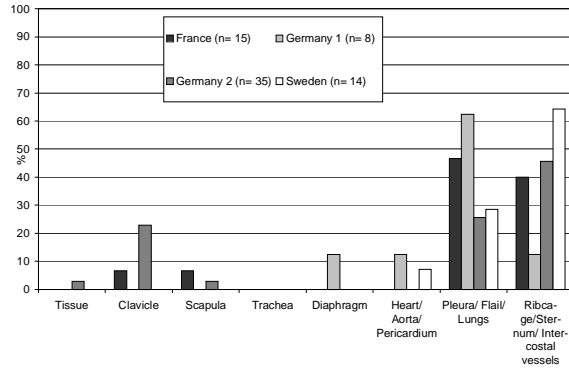
ribcage/sternum/intercostal vessels, and heart/aorta/pericardium. The group ribcage/sternum/intercostal vessels is an exception to the rule for grouping only parts subject to the same injury mechanisms, however some data sources classify these three in one group, making it impossible to separate them. For the same reason the heart/aorta/pericardium are included in one group. It is true that the members of both groups are close to each other and that an injury to one part will often coincide with an injury to another. Figure 3 shows the distribution of AIS2+ injuries to organs of the thorax for sample one. It can be seen, that the ribcage is injured most frequently amounting to approximately 50% of all injuries to the thorax. This is followed by the pleura which is also subject to frequent injury. Also affected, however not as frequently are the clavicle, heart and diaphragm. Injuries to the tissue, scapula and trachea occur only infrequently, if at all. Figure 4 indicates a similar pattern for sample two. It should be made clear, that a person might have more than one AIS2+ injury in the same body group. For example the pleura might be injured with an AIS2 and the lungs with an AIS3 injury at the same time.

The next body region is the pelvis. In the original data injury information was given for the pubic symphysis, acetabulum, pubic bone, pubic rami, ischium/ischium rami, sacroiliac, sacrum, ilium and iliac wing. Some groups were defined to obtain a larger number of significant cases per injured organ/bone. These groups consist of the pubic bone (including pubic bone, pubic rami, ischium/ischium rami), acetabulum, ilium (incl. ilium and iliac wing),

sacrum (incl. sacroilium, sacrum) and pubic symphysis. Figure 5 shows the groups formed for the pelvis. Figure 6 indicates the distribution of injuries to the pelvis for sample one.

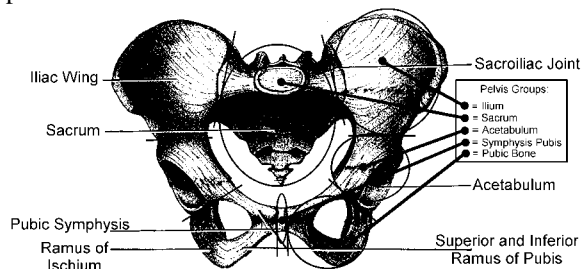


**Figure 3: Distribution of AIS2+ injuries to the thorax in car-to-car accidents in Europe: Injured part in % per nation (all injuries per nation = 100%)**



**Figure 4: Distribution of AIS2+ injuries to the thorax in car-to-fixed-obstacle accidents in Europe: Injured part in % per nation (all injuries per nation = 100%)**

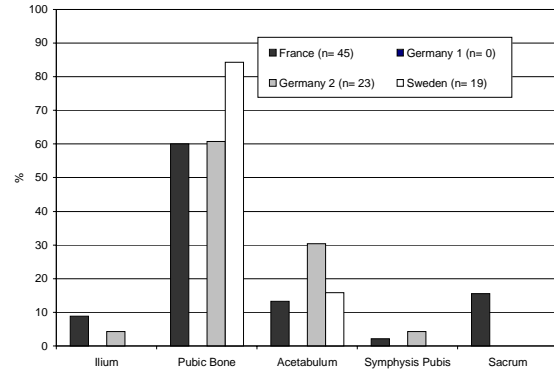
The most frequent injuries occurred to the pubic area followed by the acetabulum. Less significant are the sacrum, pubic symphysis and ilium. Figure 7 visualises the distribution of AIS2+ injuries to the pelvis in car-to-fixed-obstacle accidents.



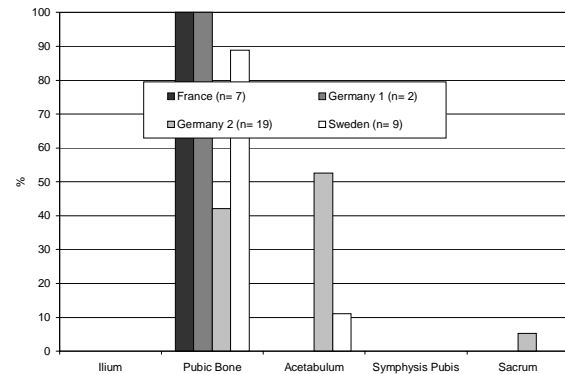
**Figure 5: Groups formed from the pelvis**

As in sample one, the primary injuries occur in the pubic area and to the acetabulum. The sacrum is

affected less frequently; the pubic symphysis and ilium are not mentioned at all.

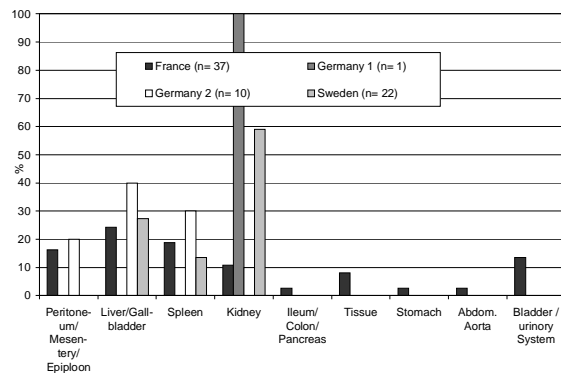


**Figure 6: Distribution of AIS2+ injuries to the pelvis in car-to-car accidents in Europe: Injured part in % per nation (all injuries per nation = 100%)**

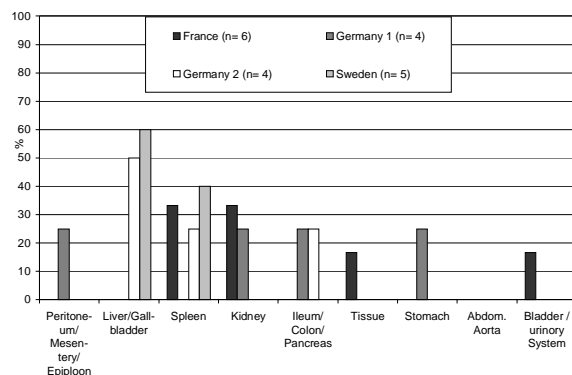


**Figure 7: Distribution of AIS2+ injuries to the pelvis in car-to-fixed-obstacle accidents in Europe: Injured part in % per nation (all injuries per nation = 100%)**

The last body region subject to further investigation is the abdomen. Although sensors are not available presently, this analysis may help to develop sensors capable of detecting abdominal injuries. The original data contains information on the mesentery, epiploon, peritoneum, liver, gall bladder, spleen, pancreas, kidneys, ileum, colon, tissue, stomach, abdominal aorta and bladder/urinary system. The groups that have been defined to summarise the data are peritoneum/mesentery/epiploon, liver/gall bladder and ileum/colon/pancreas. Figure 8 shows the distribution of injuries to the abdomen for sample one. It can be seen, that the parts most frequently subject to serious injury are the kidneys, liver/gall bladder and spleen, followed by the peritoneum/mesentery/epiploon. Less frequently affected are the ileum/colon/pancreas, bladder/urinary system, tissue, stomach and abdominal aorta. The same diagram for sample two can be seen in Figure 9.



**Figure 8: Distribution of AIS2+ injuries to the abdomen in car-to-car accidents in Europe: Injured part in % per nation (all injuries per nation = 100%)**



**Figure 9: Distribution of AIS2+ injuries to the abdomen in car-to-fixed-obstacle accidents in Europe: Injured part in % per nation (all injuries per nation = 100%)**

As in sample one, the liver/gall bladder, spleen and kidneys are of major significance, while the peritoneum /mesentery/epiploon are frequently not

mentioned at all. Therefore the ileum/colon/pancreas, tissue and stomach seem to be injured more often than in car-to-car accidents.

### Injuries to the body parts

The next step is to identify the type of injuries which occur to the various parts of the body to provide recommendations for sensor specifications to be implemented in a new SID. To do so requires a link between body part and injury. This information is not available in the data from United Kingdom and Germany1 (BMW). Therefore the investigation was accomplished only using the sources from France, Sweden and Germany2 (MUH).

All body regions and related body parts are listed in Table 3, Table 4 and Table 5 together with the various injuries of each body part. For the thorax it was found that the most significant injuries occur to the clavicle, heart/aorta/pericardium, ribcage/sternum/intercostal vessels and pleura/lungs. The only possible clavicle injury is a fracture. This is also the case for the ribcage/sternum/intercostal vessels. The primary cause for serious heart/aorta/pericardium injuries is a rupture. Rupture also occurs frequently to the pleura/lungs; but not as often as contusion, pneumothorax, haemothorax. Suffocation, crushing, haemorrhage and haematoma occur less frequently (Table 3).

The most seriously injured parts of the pelvic region were the pubic bone/pubic rami/pubic symphysis, acetabulum ischium/ ilium and, in car-to-fixed-obstacle accidents, the sacroiliac as well. For all four parts these injuries consisted of fractures and wrenching respectively (see Table 4).

**Table 3: AIS2+ injuries to the body parts of the thorax in car-to-car accidents / car-to-fixed-obstacle accidents**

Body region	Contu-sion/ Crush	Wound	Rup-ture	Frac-ture	Abra-sion	Hae-ma-toma	Hae-morr-hage	Suffo-cation	Pneu-mo-thorax	Hemo-thorax	Pain
<b>Thorax</b>											
Tissue					0 / 1						
Clavicle				11 / 9							
Heart/ Aorta/ Pericardium		1 / 0	9 / 1	0 / 1							
Scapula				0 / 2							
Ribcage/ Sternum/ Intercostal vessels			0 / 1	60 / 28							1 / 0
Pleura/ Flail/ Lungs	18 / 11		3 / 0	1 / 2		0 / 1	0 / 3	2 / 0	9 / 2	17 / 2	
Trachea			1 / 0								
Diaphragm	1 / 0	1 / 0	6 / 0								

For the abdomen the most important organs subject to serious injuries were the peritoneum/mesentery/epiploon, liver/ gall bladder, spleen and kidneys and, in the car-to-fixed-obstacle situation, also the ileum/colon/pancreas, tissue, stomach and bladder/urinary system. The injuries to the peritoneum/mesentery/epiploon include contusion, haemorrhage, haematoma and rupture (Table 5). The liver and gall bladder are subject to rupture, contusion, wounding and crushing (not frequent). The spleen/pancreas are injured mainly by rupture and contusion, but also by wounding and crushing.

**Table 4: AIS2+ injuries to the body parts of the pelvis in car-to-car accidents / car-to-fixed-obstacle accidents**

Body Region Pelvis	Fracture	Compound Fracture
Pubic bone	41/15	1/0
Acetabulum	10/10	3/0
Pubic symphysis	2/0	
Sacrum	7/0	0/1
Ilium	5/0	

**Table 5: AIS2+ injuries to the body parts of the abdomen in car-to-car accidents / car-to-fixed-obstacle accidents**

Body region Abdomen	Contusion/ Crushing	Wound	Rupture	Haematoma	Haemorrhage
Peritoneum/ Mesenter/ Epiploon	2 / 0			4 / 0	2 / 0
Liver/ Gall bladder	8 / 2	2 / 0	10 / 4		
Spleen/ Pancreas	5 / 1	2 / 0	8 / 4		
Kidneys	10 / 2		2 / 0		3 / 0
Ileum/ Colon/ Pancreas			1 / 1		
Tissue	1 / 0				2 / 1
Stomach	1 / 0				
Abdom. Aorta			1 / 0		
Bladder/ Urinary System				4 / 0	

The absolute number of injuries to the abdomen in the car-to-fixed-obstacle sample is very low so that findings are not absolutely certain. However the existing numbers indicate that the main reasons for injury are comparable to car-to-car accidents. In addition only a few singular instances of injuries to the ileum/colon, tissue, stomach and bladder/urinary system were caused by rupture, haemorrhage and haematoma.

## DISCUSSION OF RESULTS

The findings in this paper can be divided up into two categories; a general analysis of the accident situation in side impacts and the launch of requirements for the next generation of SIDs.

### General findings

In the analysed side impact configurations, injuries to the neck are much lower than in frontal accidents. This is due to the fact that only the passengers on the struck side were considered. With this type of impact the head, shoulders, possibly thorax and pelvis and legs of the person involved come into contact with the car structure. There is no possibility for free bending, tension and flexion of the neck. Therefore the neck is not subject to stresses which could lead to severe neck injuries.

It can be seen that the extremities are less important in car-to-car situations than they are in car-to-fixed-obstacle accidents. In both cases the majority of the injuries are not severe. The frequent injuries to the pelvis are rarely severe. Both facts can probably be explained by the kinematics of the occupant. When the pelvis interacts with parts of the vehicle, for instance the armrest, several other parts of the body are involved in the same manner; for instance, the shoulder and arm hit against the door. This means that the load on each part is rather moderate. Sample two (fixed obstacle) shows a much higher number of severe injuries to the pelvis. Also some other body parts such as the limbs and spine indicate that pole impact produces more serious injuries than car-to-car impact. This can also be proven by the number of injuries per occupant (see Tables 1 and 2 in the description of the data sources). Only the French data is an exception here.

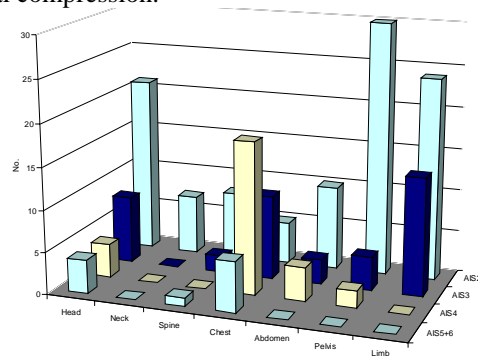
In all data sources the most important impact directions are between 9 and 10 o'clock. This fits for all except the British data, where the direction is between 2 and 3 o'clock due to right-hand traffic.

It is necessary to consider that all data comes from countries in which wearing a seatbelt has been

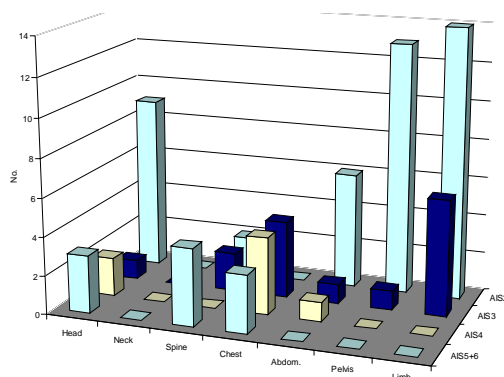
required by law for a number of years. The belt usage rate is therefore rather high (between 80 and 90 %). The British data offers the direct possibility of showing the influence of belt usage in side accidents. Figure 10 and Figure 11 visualise the distribution of severe injuries among all British impacts for sample one. The injuries to the head, spine and neck appear to be less severe when a belt is used. Therefore injuries to the thorax increase slightly although neither effect is as unambiguous as in frontal impacts.

To date only a few well documented cases are available in which the struck car was equipped with a side airbag. It appears that the risk of severe injuries is lower, and that especially injuries to the head, thorax and abdomen can be reduced significantly by such equipment.

Although it is known that particularly the abdomen is subject to serious injury, no sensors exist presently which are capable of indicating the stress and other mechanisms to the abdomen such as contusion and local compression.



**Figure 10: AIS2+ Injury distribution per body region, British data, sample one, belt buckled, (n = 187)**



**Figure 11: AIS2+ Injury distribution per body region, British data, sample one, belt not buckled, (n = 36)**

## Requirements for new SIDs

The instrumentation for a new SID to be built should include head, limb and neck instrumentation as already included on existing dummies and as proven in familiar publications. It is possible to make some additional recommendations for examining the primary injuries to the three other major body regions with injuries in side accidents (thorax, pelvis and abdomen).

Devices to indicate fractures to the clavicle, ribcage and sternum are required for the thorax region. Also desirable is the possibility of measuring values representing rupture and contusion to the areas of the heart and the lungs. If not included by the former it would be very favourable to indicate the pneumothorax and haemothorax.

For the pelvis only load sensors appear necessary. They are urgently required for the pubic bone and the acetabulum, as well as for the pubic symphysis, sacrum and ilium.

There is a strong need to indicate rupture and contusion to the liver/gall bladder, spleen and kidneys. The same is required for haematoma to the peritoneum/mesentery/epiploon and bladder/urinary system. Also haemorrhage of the kidneys and tissue are serious injuries and thus should be indicated.

## CONCLUSION

The sensoric equipment for a new SID should consist of the defined devices to indicate head, thorax, abdomen, neck, thorax, pelvis and limb injuries. The most important body regions are the head, thorax, pelvis and abdomen where the most frequent and the most serious injuries occur. The limbs are involved more often than the abdomen but the severity of the injuries is not as high. The lack of a sensors capable of measuring the injury mechanisms for abdominal injuries correctly and reproducibly prevents recording serious injuries in side impact situations. Thus there is a high requirement for such sensors.

Side airbags provide an opportunity for major safety improvement in side accidents. More and more cars will be equipped with such devices. This will make it necessary to develop new SIDs capable of measuring a wide range of mechanisms as well as the influence of side airbags, if possible, even when the passenger's position changes.

The next step is the construction of new SIDs fulfilling the stipulated requirements and the validation phase. All this will be accomplished by the consortium of the European Project SIBER and in co-operation with the WORLDSID project.

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